

FIRE IN VEGETATION: A BAD MASTER, A GOOD SERVANT, AND A NATIONAL PROBLEM.

By JOHN PHILLIPS.

Fire in vegetation is a subject of interest to all South Africans, and one upon which the man in the street considers himself adequately informed. If he has not seen for himself the ravages of fire, he has been instructed in print and by lecture that firing of vegetation is always highly destructive, and is to be considered as an act of vandalism against the national heritage. Few subjects of national interest in the Union have received more popular attention in recent years, and few have been dismissed with so definite an expression of opinion by some scientific workers and by an enthusiastic circle of the general public—that circle, chiefly resident in towns, and rightly interested in, and proud of the beautiful array of flowering plants found in the flora of South Africa. Needless to say that opinion is strongly against firing.

Largely resulting from the interest exhibited by the present Government in the national problems of veld conservation and improvement, the matter of the firing of vegetation has received renewed attention recently. It is because of this renewed interest that I attempt to deal briefly and simply with several aspects of the general problem. I dealt (Phillips 1930) some years ago, in a paper delivered to the South African Association for the Advancement of Science with a number of the influences of fire upon biotic communities in South and East Africa. I now propose to deal briefly and simply with several aspects of the problem, and shall confine my attention to considering in summarized form the evil and the beneficial influences of fire in vegetation, and to a suggestion regarding the control of fire. My hope is that my comments may call for discussion in the future, discussion based upon definite experimentation.

That the interrelations of fire, vegetation, habitat conditions, water conservation and management of various classes of vegetation provide a vast field for research of academic and practical nature, must be emphasized. Work in various regions, in various localities in each region, and at various seasons must be accomplished, and the results carefully co-ordinated and interpreted before we can possess information upon many points at present obscure.

Some work has been done by workers at the University of Cape Town, Cedara and Potchefstroom Schools of Agriculture and the Botanical Research Station, Frankenwald, University of the Witwatersrand, in recent years, but this requires to be continued and to be developed and augmented. It is to be remembered, too, that in Nature the interrelation

of grazing and browsing with fire, in terms of season, frequency of firing, and many other features, is a fundamental one, and must be given special attention. Unless such attention be given *pari passu* with the study of other aspects of the problem, data of practical value are not likely to emerge for the pastoral policies of the State and the individual.

FIRE AS A BAD MASTER.

Fire is a decidedly bad master when it is responsible for—

- (1) *Destruction or deterioration of vegetation* definitely valuable from one point of view or another. For example, valuable for its own intrinsic worth, as in the instances of timber, crops, pasturage, or because it preserves the amenities of a locality ; as in the instances of vegetation acting as a conservator of water, and of a protection forest preventing landslides and erosion upon steep slopes.
- (2) General or specific *deterioration of the physical factors of the habitat*, a deterioration brought about either directly or indirectly through the destruction or serious deterioration of vegetation.
- (3) *Destruction or deterioration of aesthetic features* of a region, landscape, or locality.

For the sake of completeness I summarise a few examples under their appropriate heads :—

(1) DESTRUCTION OR DETERIORATION OF VEGETATION.

Fire may act destructively because it destroys or impairs the value of a given plant community, and/or of the crop yielded by that community. At the same time, it may act harmfully in that it puts back to an earlier stage the ecological status of the community : a more advanced stage being replaced by a stage much, or somewhat, earlier in the plant succession. Again, it may bring about an undesirable change in the floristic and community structure of vegetation, by destroying or inhibiting development selectively, or by aiding germination, and growth from root-suckers and stump-coppice, in some species but not in others.

While fire is used in silvicultural practice with some forest species such as teak (*Tectona*), it may be looked upon as generally detrimental in its effects upon South African native forest. From the work of the Union Forest Department, it appears, too, that the use of fire in wattle culture in Natal is followed by deterioration of soil and of stand. I have outlined elsewhere (Phillips 1930) the great diminution in area of forest and scrub, as the result of the ravages of fire and axe ; I should like to record that further observations in various portions of the Union

strengthen my earlier view that woody growth of forest and scrub nature has shrunken appreciably in area during the past half century to several centuries. At the same time, I wish to advise against the general acceptance of views sometimes put forward that large portions of grass savanna, and tree-and-grass savanna in the Transvaal, Natal and the Cape Province, once—in present geological time—were under high forest. There is no field or other evidence to support such contentions. More high forest and scrub forest there undoubtedly was in various mountain and other regions of the Union—and in such sites relict stages of such vegetation still persist to tell the story; great have been the destructive influences of fire in such localities. But to claim more than this in terms of earlier extent of forest and scrub in present geological time, or in terms of the ravages of fire, cannot be supported on the facts available.

In tree-and-grass savanna of various types, and in grass savanna of probable climax nature (that is, the vegetation will develop no further than a grass stage, under present climatic conditions), it is becoming more evident as work is done upon the interrelations of fire and constitution of the grass flora, that fire may either destroy, retard, or accelerate the development of certain species. What is equally important, however, is that the season of the year and the frequency of firing over the years appear to play a fundamental rôle in this connection. Destruction of a species, or its appreciable reduction in extent, may follow on firing at one season, whereas spread of the species may result from firing at another season. In this respect the data being obtained for Themeda (*Rooigras*) at Cedara, Potchefstroom School of Agriculture, and the University of the Witwatersrand are worthy of serious consideration in connection with the use of fire in pasture-management, and the extension of experimental work of similar nature to other important species. Information collected by American workers goes to support observations being made in South Africa that firing may—according to season and frequency, and type of veld and its pastoral management—result in deterioration in terms of incoming of undesirable annual and perennial grasses, and a “weed” flora. As it is being shown, however, that judicious use of fire—along with proper management—may result in reduction of undesirable grasses and other plants and the incoming of more desirable grasses, and that the complete withholding of fire may spell deterioration in quality of veld and the influx of undesirable woody growths, it is clear that it is unfair to argue that fire in grass veld or tree-and-grass savanna is always harmful. The factor of management of the grazing after fire is so important that investigation of influences of firing, not taking cognisance of this, and not providing for the control of this process, must largely prove abortive. This aspect has well been

shown and described by Schönland (1927) in his work on the "Amatola Weed" (*Helichrysum argyrophyllum*); his recent press statements (1935) that the control of Rhenosterbos (*Elytropappus rhinocerotis*) by fire is possible, provided there is adequate grazing control, are further enlightening in this respect.

"Fijnbos" (macchia or maquis of the S.-W. Cape) vegetation, in almost all of its types productive of some of the most beautiful flowers of our flora, has suffered severely by annual ravages by fire. To this undoubtedly unfortunate fact is due much of the agitation against veld firing. It is a melancholy fact that some forms have disappeared entirely, and that others rapidly are becoming more and more rare; forms resistant to fire, and even benefitting from the stimulus given their cambium to produce fresh shoots, are becoming more abundant; unfortunately, such resistant forms are not always the more beautiful ones. Early sprouting and flowering of bulbous forms, some of them with showy flowers (such as various Iridaceae, Liliaceae, Amaryllidaceae, Orchidaceae) by some is claimed as a compensation for the formation in fijnbos of a blackened wilderness of charred stems and branches; it surely is a poor one at best. Firing does, of course, temporarily improve the browse and grazing, poor in the best of conditions—hence its being practised by owners of sheep and other stock. Lack of attention to season of firing, and frequency of repetition, however, probably result in gradual deterioration of browse and grazing—a point requiring experimental work in various types of fijnbos. The results of work being conducted by Adamson and Levyns in regard to fire and fijnbos are awaited with interest.

Destruction of exotic vegetation requires no special comment, except that it is necessary for us to remember that our increasing plantations of exotic trees call for the awakening of a national consciousness as regards their protection against fire. Through various forestry and silvicultural difficulties which need not be mentioned here, the Forestry authorities of the Union largely have to rely upon plantings of highly inflammable conifers, the protection against fire of which is by no means an easy task. Plantations of Eucalypts (Gums), although frequently devoid of vegetation beneath their own canopy, owing to their strong reaction upon soil-moisture, are liable to scorch and burn readily: development of fresh growth from adventitious buds, however, usually follows rapidly and profusely from a fire. The use of Gums for living fire-breaks, in my opinion, is strongly undesirable, because to me they appear to be more in the nature of "fire-traps" than "fire-guards." Fire sweeping through plantations of exotic Acacias (such as *A. mollissima*, *A. dealbata*, *A. decurrens* (Green Wattle), *A. melanoxylon* (Blackwood)) produces the undesir-

able effect of strong reduction in organic matter, which reduction is certainly a cause cognate with that of the reaction of the trees themselves, in reducing water content of the soil, through removal of the water-absorbing, water-holding mulch of decomposed and undecomposed wood and leaf litter. Chemical ingredients in the litter are lost, to some extent, in the gaseous form during combustion, and possibly also by subsequent blowing by wind and washing by water, of the inorganic ash.

(2) DETERIORATION OF HABITAT.

As I have elsewhere (Phillips 1930) discussed in some detail the influence of fire upon aerial and soil factors, and as a really adequate additional treatment would require much space, and indeed still requires much more analytical work by physicist, chemist, and soil-biologist, I confine myself to a few general observations.

Firing invariably—if for a short period only—results in the aerial factors of greater importance—light-intensity, sun-temperature, true aerial or shade-temperature, humidity, wind-rate, evaporativity (the complex of light, heat, humidity, wind)—being made more severe than they were before the fire, upon the surface of the soil. Soil temperature (surface, and to a depth of several inches), organic matter, acidity, water-supplying-power, and total chemical solutes available to plants, are caused to change to a greater or lesser degree. Soil organisms—notably soil bacteria, fungi, protozoa, earthworms, and insects—in the upper layers, are influenced directly by the heat of the fire, or indirectly by the change in aerial and soil factors following removal of the vegetation cover. Frequently such physical, chemical and biological changes are in the direction of deterioration, although, as mentioned later, certain classes of soil over-charged with organic matter undoubtedly derive benefit from being fired at well spaced intervals.

While edaphic changes proper are of great importance to the forester, the agriculturist and the pastoralist, it is principally through an increase in rate of run-off of water and a decrease in rate and extent of water-absorption by the soil, that fire brings about major deterioration in a locality. Removal of vegetation, or its thinning, by fire is the first stage helping rain water to rush down slopes, or flow relatively unabsorbed over indurated soil of more level nature; burning of the organic matter zone in the uppermost layers of the soil is the next stage. While vegetation and organic matter destruction may spell temporary and local increases in run-off, benefitting for a short time streams, rivers, and vleis, it is quite clear that supplying-power of the site, for water courses and water bodies for which it forms the catchment, is greatly reduced in terms of amount at any given period, and of efficiency during periods of prolonged drought.

Rapid run-off, as is well known, is accompanied by sand, silt and solutes, leading to a physical and chemical impoverishment of the soil.

It is because of the alteration by fire of the balance between water lost and water absorbed, and later steadily supplied, that the firing of vegetation in water catchment regions—such as mountain tops and slopes, valleys and along river courses—is so strongly deprecated. *Such regions should not be "farmed," for farming in South Africa is too frequently associated with either uncontrolled firing of vegetation, or over-stocking—both practices resulting in diminution of the water-supplying capacity of springs and other sources of water.*

Induration of the soil surface by fire, aided by temperature, humidity, and evaporation conditions following on its exposure to full insolation, not only is undesirable on account of its assisting rapid run-off of water, but because of the physical obstacle it sets to radicles of germinating seeds.

With regard to the often debated matter of early and very dense growth of grass and other shoots upon fired areas, as contrasted with the phenomena presented on unfired areas adjacent, observations made by my students and myself since 1931 go to support the view that this is no illusion, and probably is due to increased physiological activity in the direction of utilisation of root-reserves, in response to higher temperature conditions during the day, on the exposed and blackened soil of fired areas.

(3) DESTRUCTION OR DETERIORATION OF AESTHETIC FEATURES.

As has been indicated already, fire has caused loss of beautiful plants, more especially in the fynbos of the South-Western Cape. Year by year we are becoming more conscious of the glory of the floral wealth of our country, in its various types. If in detail many of the plants of the more arid portions are not spectacular in their form and colour, we are beginning to appreciate the general effect produced by natural vegetation upon ranges of hills, on kopjes, and lining valleys and water courses. Fire, coupled with a somewhat careless farming practice, undoubtedly is converting many aesthetically charming vegetation and landscape vistas into untidy, unsightly, much scarred spectacles. The most ardent advocate of the benefits of using fire in veld management scarcely could subscribe to the annual burning off of vegetation upon areas of scenic attraction, where frequently the grazing to be won by the firing is of a very low order anyway.

FIRE AS A GOOD SERVANT.

Controlled firing of vegetation, controlled in regard to season and frequency, for a given class of vegetation within a given climatic or soil region, undoubtedly has much to be said in its favour.

It is the avowed policy of the Union Department of Agriculture to develop the pastoral industry. Such development calls for a fundamental improvement in present methods of browsing and grazing of natural vegetation. Important aids to production of better natural pastures—that is naturally established and not planted or sown vegetation, even if of South African plants—are known to be the following :—(1) Controlled grazing, with adequate provision for rotation and rest ; (2) fertilizing, to improve the quality and increase the quantity of growth ; (3) superficial cultivating of the soil, so as to improve conditions for basal spread of grasses : (4) mowing, to provide food for winter, but also to prevent grass from becoming too tall, too rank, and from developing, by process of plant succession, to less and less desirable community stages.

It is to be remembered that mowing is possible only upon areas of suitable topography and level, and is impossible upon steep slopes, in broken country, and where stones and termite mounds are abundant.

Firing costs little or nothing, apart from the making of fire-breaks, is rapid, and is everywhere effective unless attempted either too early in autumn or too late in the spring. If the correct season be selected for the particular class of community, a desirable stage in the succession in the grass savanna or in the tree-and-grass savanna may either be maintained or encouraged by firing plus suitable management of the grazing. While firing has been the practice in the *fijnbos* of the South-Western Cape for several centuries, we still know less about the seasonal features and the more suitable methods of management after firing this class of vegetation, than is the case regarding the grass and the tree-and-grass communities. From my own experience in the *fijnbos* of the George—Knysna region, I am strongly inclined to the view that experimental work relatively soon would show one season to be more suitable than another, so far as obtaining the best increase in browse or grazing, and the minimum development of poisonous Monocotyledons such as the *Moreas*, *Homerias* and *Urgineas*. Firing of *fijnbos* in accordance with a seasonal plan, and at intervals of several years, would give the farmer more suitable browse and grazing, and would not impair soil conditions or mar the aesthetic features to the extent for which annual firing is responsible.

Grazing shortly or mowing grass has the effect of causing somewhat earlier shooting than is the case upon ungrazed, or lightly grazed areas adjacent ; firing has an even more pronounced effect. This effect can be turned to utility in such areas where undesirable grasses it is required to reduce or eliminate, shoot markedly before the better grasses. The efficacy of controlled firing, followed by early shooting of undesirable species such as *Elionurus argenteus* (Zuurpol), *Aristida angustata* (Besem-gras), *Tristachya Rehmannii* (Blaauwdraadgras), and *Eragrostis* spp.,

which are grazed off by controlled movement of stock, is being proved upon experimental plots at the Botanical Research Station, Frankenwald. Work in other grass communities probably would show the method to have use therein as well.

It is becoming abundantly clear from observations in various parts of the country, in which there is a marked increase in Acacias such as *A. Karroo* (Zoetdoring), *A. caffra* (Kaffer Wag 'n bietje), *A. robusta* (Brosdoring), *A. permixta* (Fijndoring), *A. litakunensis* (Haak-en-steek), and other large woody shrubs such as *Gymnosporia* spp., *Zizyphus mucronata* (Blinkblaar) and *Dichrostachys glomerata* (Sikkelbos)—where representatives of these species occur naturally—that withholding of fire, in combination with overstocking, has been responsible for this accelerated increase in woody growth. My interpretation is this: in areas where such woody growths appear, they by nature form the climax vegetation, a Thorn or Mixed Scrub. Ever-recurring fires in the grass communities associated with them, has in time past, prevented their attaining a general dominance. Over-stocking has removed or eased the competition previously existing between scrub and grass for water and solutes, and at the same time has been the cause of elimination or strong reduction in grass fires always somewhat detrimental to the shrubs: hence the accelerated growth and influx of woody growth, serving as an example of what I have termed (Phillips 1934) succession-acceleration. Protection of such poorly grassed, shrub-dense areas against grazing for a season or two, with subsequent controlled firing of the grass that would appear in the glades, would go a long way toward improving their pastoral value. Thinning of the scrub by felling or poisoning—for example by spraying smaller growth with 5 per cent. sodium chlorate—would aid the good work of the controlled fires.

Periodic controlled burning of grass has a further good effect, in that it destroys old growth liable to be infected by micro-organisms suspected to be associated with stock diseases.

Where soils over-rich in organic matter, much of it but very incompletely decomposed, have to be utilised for agricultural or forestry purposes, firing of the vegetation and of the excess organic accumulation certainly improves the conditions for cultivation and growth.

Fortunately the Union has but a relatively small extent of country under tsetsefly (*Glossina pallidipes*, in portion of Zululand). In Central Africa, where vast areas are under influences of one or other species of the genus, protection of grass for several seasons, and ultimate controlled firing of this and patches of dense woody growth utilised for depositing of the larvae and development of the puparia and imagoes, has been responsible for reduction in number of fly; combined with bush clearing, it has freed areas for human habitation and grazing.

A SUGGESTION TOWARDS THE SOLUTION OF THE NATIONAL PROBLEM.

While we would agree that the building up of an enlightened public opinion would be the best protection possible against abuse of fire, and indeed should be the aim of scientific workers, agriculturists, foresters and educationalists to attain in time, it is perfectly plain that we cannot await such a time as shall see the average farmer gifted with both knowledge and a sensitive conscience. Vegetation, soil, and water supply are annually being lost. Hence action is urgently necessary.

I consider the rational procedure to be much as described below :—

(1) We must make up our minds that, for present purposes, certain classes of locality demand protection from all kinds of grazing, browsing, and firing, and that certain other classes demand early application of controlled firing ; the remainder of the country we must leave unattended until the more important portions have been dealt with satisfactorily. So far as complete protection from grazing, browsing and firing is concerned, I consider the classes of locality to embrace (i) all important catchment areas feeding water supplies utilised either for human consumption or for irrigation ; in practice, such would be certain mountain tops and slopes, valleys and water-course ravines ; (ii) certain mountain and other areas unquestionably suitable for conservation and improvement of natural forest, and for planting and proper management of suitable exotic trees required for timber or other purposes. Areas urgently calling for attention in terms of controlled grazing, browsing and firing include some of the more important coastal and inland mountain regions, and less important catchment areas generally.

(2) Responsibility for investigating the principal general features of the problems set in the two classes of locality to which is made above, and for arranging for the execution of more detailed studies by men of adequate training, should be vested in a special Commission or Department of the Government. Such a Commission of Conservation should be under the chairmanship of the Minister of Agriculture and Forestry, and should include senior representatives of the following Departments : Agriculture and Forestry, Veterinary Science, Irrigation, Native Affairs, Railways, National Roads Board, Police, Education, Union and Provincial. Such a Commission should have power to co-opt for special purposes representatives of Farmers' Associations. It will require legal advice. Such a Commission should proceed to consider, *inter alia*, the following highly important matters :—

- (i) The legal aspects of appropriation of certain localities for complete protection ; the study of appropriation in relation to both existing legislation and that which is requisite to the purpose to be achieved.

- (ii) The legal mechanism as well as the practical mechanism for institution of a policy of controlled grazing, browsing and firing within specified classes of area.
- (iii) The classification of areas in terms of (i) and (ii) above, based upon the information and guidance of scientific and other suitably trained officers.
- (iv) The formulation of a policy for each important area concerned, based upon information of scientific and other suitably trained officers.
- (v) Details of the mechanism for enforcement of protection and of control, without which the whole scheme would fail—a law being only as strong as the force behind it. Matters of staff, patrolling, reporting, provision of notices, and provision of adequate fire-breaks would require careful consideration, organisation and financial support. Co-ordination of functions of the several Departments concerned would be essential to smooth working and success; details would vary with each portion of the country, the Department best suited to assume local responsibility, and the like.
- (vi) The most suitable methods of imparting education regarding the objects of the Commission, and the national importance of successful achievement of such.

It must be emphasised that under present circumstances uncontrolled firing is costing this country untold millions, and is creating for posterity a most serious state of affairs, which no amount of money ever would be capable of putting right. Expenditure, even of relatively large sums, is therefore amply justified.

SUMMARY.

(1) The influence of fire in vegetation is discussed on account of the renewed interest shown in the matter, since the adoption by Government of a policy of veld improvement.

(2) An attempt is made to indicate both the harmful and the beneficial influences of fire. Certainly destructive when uncontrolled, fire may be turned to good utility when regulated according to objects of management, season, frequency, and locality.

(3) An outline is given of the procedure considered to be necessary before adequate control of fire could be possible. A special Conservation Commission is suggested, and some of its principal duties are discussed briefly.

REFERENCES.

- PHILLIPS, JOHN, 1930: Fire: Its influence on biotic communities and physical factors in South and East Africa. S. Afr. Journ. Sci. 27: pp. 352-367.
- PHILLIPS, JOHN, 1934: Succession, development, the climax and the complex organism: an analysis of concepts. Part I. Journ. Ecology, 22 (2), pp. 554-71.
- SCHÖNLAND, S., 1927: On the reclamation of ruined pasturage on the Amatolas, near Keiskama Hoek. Dept. Agric. Sci. Bull. 55.
- SCHÖNLAND, S., 1935: Memorandum to Grahamstown Divisional Council, on Rhenosterbos; report in "Star," 22/5/1935, p. 12.
-